

SYSTEM FOR GENERATING A TRIGGERING SIGNAL FOR RESTRAINING  
MEANS AND METHOD FOR TRIGGERING RESTRAINING MEANS IN A VEHICLE

Background Information

The present invention relates to a system for generating a triggering signal for restraining means in a vehicle, the restraining means being provided for the event of a collision  
5 of the vehicle, such as a head-on collision or a side impact. To that effect, the system includes means for detecting an impact which, in the event of an impact, generate a request signal for the restraining means corresponding to the type of impact. Means for detecting a rotational motion of the vehicle  
10 about at least one vehicle axis - longitudinal axis (x) and/or transverse axis (y) - are additionally provided. These means generate a corresponding status signal.

Furthermore, the present invention relates to a method for triggering restraining means which are provided for the event  
15 of a collision of the vehicle. In addition to information about a possible collision of the vehicle, information about a possible rotational motion of the vehicle about at least one vehicle axis - longitudinal axis (x) and/or transverse axis (y) - is collected and analyzed as well in this method.

20 In the vehicles known from practice which are equipped with restraining means, triggering of the restraining means in accidents involving a head-on collision or a side impact normally takes place independently from the circumstances of the accident. In particular, it is not taken into account in  
25 the known triggering algorithms whether a rollover takes place or has already taken place during the course of the accident.

Due to this fact, the driver airbag and the front passenger airbag may be deployed, for example, even though the vehicle is lying on its roof after a rollover, the passenger compartment has been made smaller by the rollover, and the passengers are situated in an undefined position. If the vehicle lands on its side during a rollover, triggering of the particular side airbag is at least critical when a vehicle passenger is situated directly above the side airbag. Overall, practice has shown that in accidents in the course of which a critical rotational motion of the vehicle occurs in addition to an impact, a not negligible injury risk for the vehicle passengers emanates from triggering the restraining means provided for the impact situation. Protection of the vehicle passengers may be improved in that the circumstances of the accident are taken into account in the decision about triggering the restraining means

#### Advantages of the Invention

It is proposed with the present invention to refine the criterion for triggering the restraining means provided for impact situations. To this end, information about the possible occurrence or existence of a rotational motion of the vehicle should be taken into account in the decision about triggering these restraining means. According to the present invention, this is implemented in a system of the type mentioned above by using a circuit which, for generating a triggering signal, combines the request signal and the status signal - and thus the information about the circumstances of the accident.

The present invention is based on the perception that it is reasonable to coordinate the use of all restraining means situated in the vehicle, in particular when the vehicle rolls over during the course of an accident, or when the vehicle experiences a critical rotational motion in which the vehicle

topples over on the side, for example. In addition, it is recognized according to the present invention that in such accidents triggering of the restraining means, which are supposed to protect the vehicle passengers during a critical rotational motion of the vehicle such as a rollover, has a higher priority than triggering of the restraining means provided for impact situations. Therefore, the criterion for triggering these restraining means will be refined according to the present invention. According to the present invention, information is used for refining the triggering criterion which is collected and analyzed for determining a critical rotational motion of the vehicle since the position and the state of the vehicle, as well as the position of the passengers in the passenger compartment, may be estimated relatively easily using this information. On the basis of this estimation, it may then be better decided whether it is sensible or even detrimental to the protection of the passengers to trigger the restraining means provided for the present impact situation.

There are basically different possibilities for implementing the system according to the present invention and the method according to the present invention.

As a particularly advantageous variant of the present invention it is proposed to block the restraining means in the event of an impact situation for a defined period of time  $t_{\text{stop}}$  when a critical rotational motion of the vehicle has been recognized. The circuit of the system according to the present invention includes at least one hold element for this purpose, with which period of time  $t_{\text{stop}}$ , in which no triggering signal may be generated, is determined. The circuit and the hold element in particular are designed in such a way that, in the event of a collision, the restraining means are only blocked when additionally a critical rotational motion is also

recognized. For this purpose, the information about the possible occurrence or existence of a rotational motion of the vehicle is analyzed based on one or also multiple criteria which may differ from vehicle type to vehicle type and may be predefined by the vehicle manufacturer.

When the vehicle rolls over prior to impact, it is oftentimes reasonable to block or at least to delay triggering of the restraining means. In order to recognize such situations, the vehicle's instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) is detected and analyzed in an advantageous variant of the present invention. Whenever the instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) exceeds a first appropriately selected threshold value ( $\alpha_{x \min 1}$  and/or  $\alpha_{y \min 1}$ ) it is assumed that a rollover is taking place or has taken place, which is recognized as a rotational motion in the context of the present invention.

Furthermore, it may be reasonable to block or at least to delay triggering of the restraining means as soon as a rollover is predicted, i.e., the vehicle has not yet rolled over, but a rollover is imminent. For recognizing such situations it is proposed according to the present invention to also detect and analyze the vehicle's instantaneous angular velocity ( $\omega_x$  and/or  $\omega_y$ ) in addition to the instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ). A rollover may be easily predicted in this case and the existence of a critical rotational motion may thus be assumed when the instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) exceeds a second appropriately selected threshold value ( $\alpha_{x \min 2}$  and/or  $\alpha_{y \min 2}$ ), and when the instantaneous angular velocity ( $\omega_x$  and/or  $\omega_y$ ) also exceeds an appropriately selected threshold value ( $\omega_{x \min}$  and/or  $\omega_{y \min}$ ).

It should be noted at this point that the occurrence of a rollover may be recognized or predicted using other motion parameters which may likewise be detected and analyzed with

the help of a system according to the present invention and within the scope of the method according to the present invention. In addition, other or more rotational motions of the vehicle may be defined as being critical.

5 As already mentioned, the criteria on the basis of which a possible rotational motion of the vehicle is classified as being critical or uncritical may be determined by the vehicle manufacturer for example. In addition, period of time  $t_{\text{stop}}$  in which the restraining means are blocked may be determined  
10 individually, namely not only dependent on the vehicle type but also dependent on the circumstances of the accident. In the event of an impact, the restraining means may be blocked permanently ( $t_{\text{stop}} = \infty$ ) for example or only for a limited period of time ( $t_{\text{stop}} = \text{const.}$ ) when a critical rotational motion has  
15 been recognized.

Oftentimes it is advantageous to block the restraining means at least until the vehicle has come to rest. To determine this, a third threshold value for the instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) for example may be defined. If the  
20 instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) falls below this third threshold value ( $\alpha_{x \text{ min3}}$  and/or  $\alpha_{y \text{ min3}}$ ) it may be assumed that the vehicle has come to rest. Detecting and analyzing the vehicle's instantaneous linear acceleration ( $a_x$ ,  $a_y$  and/or  $a_z$ ) presents another possibility. In this case, for example, it  
25 may then be assumed that the vehicle has come to rest when a function of the instantaneous linear acceleration  $f$  ( $a_x$ ,  $a_y$  and/or  $a_z$ ) falls below a defined threshold value  $a_{\text{min}}$ .

#### Drawings

As discussed in greater detail above, there are different  
30 possibilities for developing and refining the teaching of the present invention in an advantageous manner. For this purpose reference is made to the patent claims subordinated to the

independent patent claims and to the following description of multiple exemplary embodiments of the present invention based on the drawing.

Figures 1a through 1c each show a block diagram of a system according to the present invention for generating a triggering signal for restraining means in a vehicle.

Figures 2a through 2d each show a block diagram for a possible implementation of the hold element of a system according to the present invention.

#### 10 Description of the Exemplary Embodiments

The variants of a system 1, 2, or 3 according to the present invention described in the following in connection with Figures 1a through 1c are each used for generating a triggering signal for restraining means in a vehicle, the restraining means being provided for the event of a collision of the vehicle, such as a head-on collision or a side impact. All three variants include means 4 for detecting a collision and which, in the event of an impact, generate a request signal 5 for the restraining means which are appropriately provided for the existing type of impact. In addition, means 6 and/or 7 for detecting a rotational motion of the vehicle about at least one vehicle axis - longitudinal axis (x) and/or transverse axis (y) - are provided in all three variants. These means generate a corresponding status signal 8 or 9.

According to the present invention, each of systems 1, 2, or 3 includes a circuit 11, 21, or 31 for generating a triggering signal 10 which combines request signal 5 and status signal 8 and/or 9 so that information about a possible occurrence or the existence of a rotational motion is taken into account in the decision about triggering the restraining means.

In each of the illustrated exemplary embodiments, circuit 11, 21, or 31 includes a hold element 13 whose function only becomes effective when a critical rotational motion has been recognized. In these cases, hold element 13 causes the

restraining means to be blocked for a period of time  $t_{\text{stop}}$  in the event of an impact. Hold element 13 is designed in such a way that it otherwise does not affect the triggering of the restraining means or the generation of a corresponding triggering signal. The different possibilities for

implementing such a hold element 13 are explained in greater detail below in connection with Figures 2a through 2d.

In system 1 illustrated in Figure 1a, means 6 make it possible to predict whether a rollover is to be expected, i.e., whether a vehicle rollover is imminent. Such a prediction may be

based, for example, on information about the vehicle's instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) in connection with information about the vehicle's instantaneous angular velocity ( $\omega_x$  and/or  $\omega_y$ ). In this case, a rollover is always predicted when the instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) exceeds a corresponding threshold value ( $\alpha_{x \text{ min}2}$  and/or  $\alpha_{y \text{ min}2}$ ) and when the instantaneous angular velocity ( $\omega_x$  and/or  $\omega_y$ ) also exceeds a corresponding threshold value ( $\omega_{x \text{ min}}$  and/or  $\omega_{y \text{ min}}$ ). Status signal 8 is inverted at point 12. Inverted status signal 8' is supplied to the input of hold element 13, the output signal of which is combined with request signal 5 at point 14. Depending on the state of request signal 5 and status signal 8 and depending on the type of hold element 13, a triggering signal 10 for the restraining means is generated as a result of this combination.

During an occurring impact situation, request signal 5 is at logic 1. Normally no rollover is predicted so that status signal 8 is at logic 0 and correspondingly inverted status signal 8' is at logic 1. As long as no rollover is predicted,

hold element 13 transfers the state of inverted status signal 8' directly to downstream AND gate 15. Since a logic 1 is applied to both inputs of AND gate 15, a triggering signal 10 for the requested restraining means is generated.

- 5 If a rollover is predicted during an occurring impact situation, status signal 8 is at logic 1 and correspondingly inverted status signal 8' is at logic 0. This state is sustained by hold element 13 for a defined period of time  $t_{stop}$  so that logic 1 and logic 0 are applied to AND gate 15. Only  
10 after  $t_{stop}$  has elapsed is the then applied instantaneous inverted status signal 8' which, as mentioned, is normally at logic 1 supplied to AND gate 15. Accordingly, only after expiration of  $t_{stop}$  is a triggering signal 10 generated for the requested restraining means.
- 15 In system 2 illustrated in Figure 1b, triggering of the restraining means at a collision of the vehicle should only be blocked or delayed when a rollover actually occurs, which is determined using means 7. The vehicle's instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) is monitored for this purpose and  
20 compared with a corresponding threshold value ( $\alpha_{x\ min2}$  and/or  $\alpha_{y\ min2}$ ). The existence of a rollover situation is assumed when the instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) exceeds this threshold value ( $\alpha_{x\ min2}$  and/or  $\alpha_{y\ min2}$ ) and status signal 9 is set to 1. Otherwise the system illustrated in Figure 1b is  
25 identical to the system illustrated in Figure 1a.

Means 6 described in connection with Figure 1a, which allow the prediction of a rollover, and means 7 for detecting a rollover described in connection with Figure 1b are combined in system 3 illustrated in Figure 1c so that the function of  
30 hold element 13 only becomes effective when a rollover is predicted and when instantaneous angular position ( $\alpha_x$  and/or  $\alpha_y$ ) exceeds a certain threshold value ( $\alpha_{x\ min2}$  and/or  $\alpha_{y\ min2}$ ).



Both status signals 8 and 9 are supplied to an AND gate 16 whose inverted output signal then forms the input signal for hold element 13. Otherwise the system illustrated in Figure 1c is identical to the systems illustrated in Figures 1a and 1b.

5 It should be noted at this point that the threshold values for the angular positions  $\alpha_{x \min 1}$  and/or  $\alpha_{y \min 1}$  and  $\alpha_{x \min 2}$  and/or  $\alpha_{y \min 2}$  and the threshold value for the angular velocity  $\omega_{x \min}$  and/or  $\omega_{y \min}$  may not only be determined for each space direction x and y but also individually for each restraining  
10 means. Due to this fact it may be achieved, for example, that triggering of the restraining means in head-on accidents is only blocked when the vehicle has rotated about its x- axis or y-axis by at least 180 degrees. It must be assumed in these cases that the roof has been pushed in and the passenger  
15 compartment has become smaller. In contrast, the restraining means assigned to a side impact should be blocked as soon as the vehicle has rotated about its x-axis by at least 90 degrees. The passengers are normally in an unfavorable position in this case so that triggering of a side airbag  
20 represents an additional injury risk.

As mentioned earlier, different possibilities 131, 132, 133, and 134 for implementing a hold element are illustrated in Figures 2a through 2d.

In the variant illustrated in Figure 2a, hold element 131  
25 causes a permanent block ( $t_{\text{stop}} = \infty$ ) of the restraining means assigned to the particular impact situation when a critical rotational motion of the vehicle has been recognized.

In the variant illustrated in Figure 2b, the restraining means assigned to the particular impact situation are only blocked  
30 for a limited, defined period of time ( $t_{\text{stop}} = \text{const.}$ ) when a critical rotational motion of the vehicle has been recognized.

In the variants illustrated in Figures 2c and 2d, the restraining means are blocked in the event of an impact at least until the vehicle has come to rest after a critical rotational motion was detected. In order to detect whether the vehicle has come to rest, the roll angular velocity  $\omega_x$  or the pitch angular velocity  $\omega_y$  and the vehicle's three linear accelerations  $a_x$ ,  $a_y$ , and  $a_z$  are monitored. Using hold element 133 or 134, it is monitored at point 135 whether the angular velocities  $\omega_x$  and  $\omega_y$  fall below a correspondingly defined threshold value  $\omega_{x \min 3}$  or  $\omega_{y \min 3}$  and it is monitored at point 136 whether a function  $f(a_x, a_y, a_z)$  falls below a threshold value  $a_{\min}$ . This function  $f(a_x, a_y, a_z)$  may be implemented, for example, as  $f(a_x, a_y, a_z) = |a_x| + |a_y| + |a_z|$  or as  $f(a_x, a_y, a_z) = \max. (|a_x|, |a_y|, |a_z|)$ . If one of these two conditions or both conditions are met it is assumed that the vehicle has come to rest. The combination of the respective signals is implemented here using an AND/OR gate 137. The output signal of this AND/OR gate is supplied to a first hold element 138. In the case of the variant illustrated in Figure 2c, hold element 138 cancels the block of the restraining means when the vehicle has come to rest. In the case of the variant illustrated in Figure 2d, the block of the restraining means is sustained over an additional defined period of time  $t$ , even when the vehicle has already come to rest. A second hold element 139 downstream from first hold element 138 is provided for this purpose.